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IMPROVEMENTS IN PACK DESIGN AT LINGAN COLLIERY

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IMPROVEMENTS IN PACK DESIGN AT LINGAN COLLIERY

by

P. Cain*

ABSTRACT

In 1985 the Cape Breton Development Corporation made design changes to maingate and tailgate packs at Lingan Colliery. Monolithic pumped packing was implemented in the maingate on the 9E District to improve face end ventilation by limiting gob leakage. The tailgate packs on the 9E and 6W Districts were redesigned after strata control investigations in other districts had shown that they offered inadequate resistance to control gate-road deformation.

Both packing changes were monitored by the CANMET Coal Research Laboratory in Sydney. The results of the monitoring programme illustrating the beneficial effects of the packing changes are described.

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REMBLAIS DE CONCEPTION AMÉLIORÉE À LA MINE DE CHARBON LINGAN

par

P. Cain*

RÉSUMÉ

En 1985, la Société de développement du Cap-Breton a modifié la conception des remblais des voies de base et de tête à la mine de charbon Lingan. Dans la voie de base du district 9E, on a eu recours au remblayage monolithique par pompage pour améliorer la ventilation à l'extrémité du front en limitant les fuites dans les remblais. Les remblais de voie de tête des districts 9E et 6W ont été repensés après que des analyses du contrôle du toit effectuées dans d'autres districts ont montré qu'ils résistaient mal à la déformation des voies de taille.

Les modifications apportées au remblayage ont été surveillées par le Laboratoire de recherche sur le charbon de CANMET à Sydney. Les résultats du programme de surveillance illustrant les avantages de ces modifications sont présentés.

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INTRODUCTION

In 1985 the Cape Breton Development Corporation (CBDC) made major changes in gateroad support in response to operational problems. Packing changes were made in the 9E Maingate and the 6W Tailgate. Both changes have proved so successful that they are currently being planned or implemented elsewhere in the mine.

The loss of large quantities of ventilating intake air to return airways by leakage through the maingate packs has long been recognised as a problem at Lingan Colliery, especially on the east side panels (Figure 1) (1,2). Production scheduling at the colliery in 1985 required the simultaneous extraction of two adjacent longwall faces, 8E and 9E, which precluded the use of the most effective leakage control method previously utilised, 'cundy ventilation' (Figure 2). In an effort to prevent gob leakage and allow safe and efficient production from both active east side panels, the Cape Breton Development Corporation (CBDC) decided to implement a monolithic pumped packing trial on the 9E Maingate.

In the tailgates at Lingan Colliery conventional packing was not controlling strata movement. Convergence of the gateroad, as a result of poor strata control, was disrupting activities in the tailgate. Conventional packing in the tailgate consisted of stone rubble with a 60% solid hardwood chock and three skeleton cribs. CBDC decided to implement a new support method to improve gateroad conditions. The new support consisted of larger arches and a continuous row of 1.5 m x 1.5 m solid hardwood chocks. This method was first used in the 6W District. It proved so successful that it was also implemented in the 9E Tailgate.

The Cape Breton Coal Research Laboratory (CBCRL) was asked to investigate the effects of the new support techniques on gateroad strata control. This report describes the findings of the investigations carried out in the trial gateroads at Lingan Colliery.

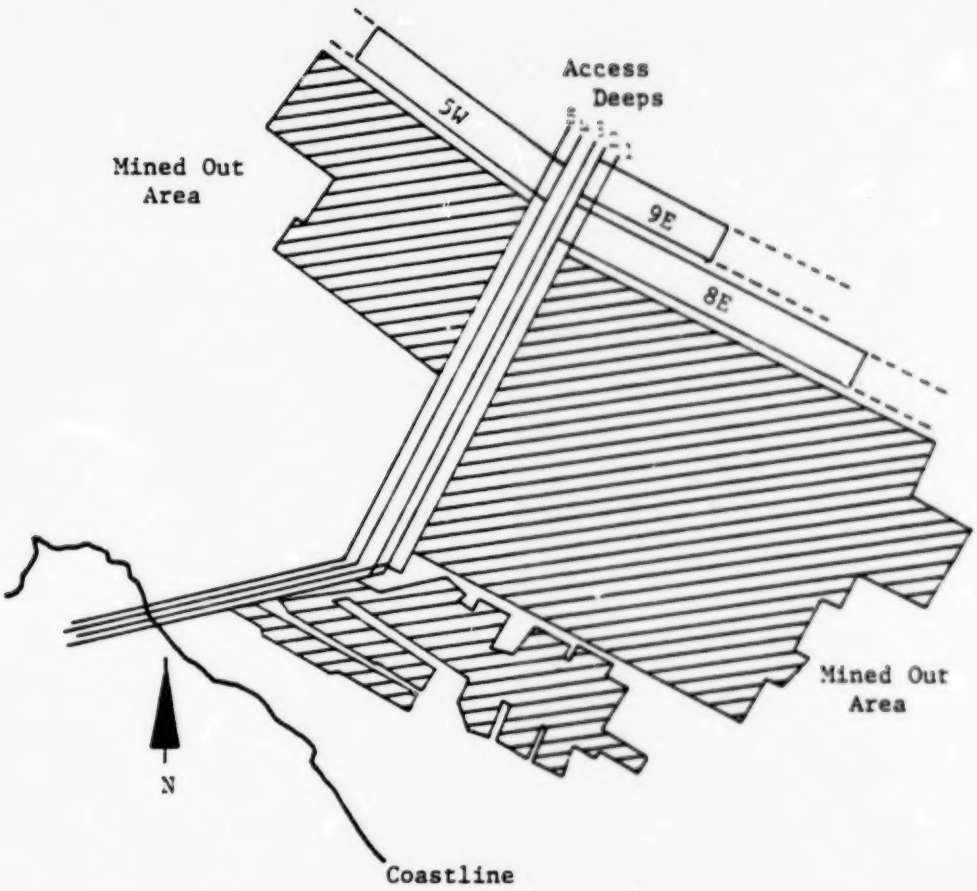

Figure 1 - Lingan Colliery, New Waterford, Nova Scotia

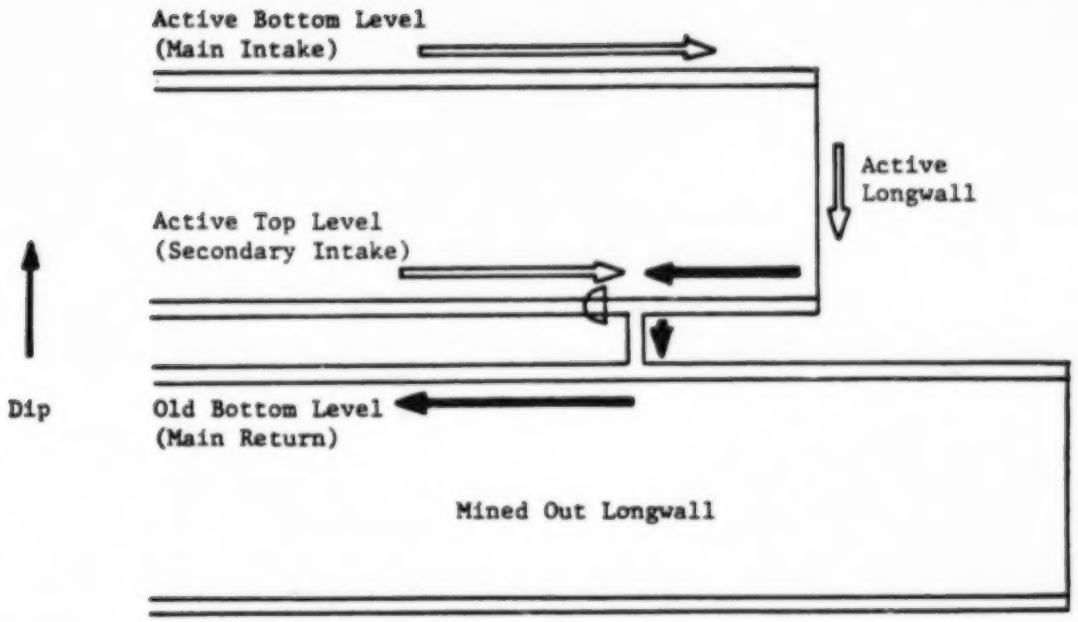

Figure 2 - 'Cundy ventilation' as practised at Lingan Colliery

DETAILS OF THE DISTRICTS

MINING PARAMETERS

Both the 9E and 6W Districts are advancing longwall coalfaces in the Harbour Seam at Lingan Colliery (Figure 1). Coal is extracted by 200 kW Anderson Strathclyde double ended ranging drum shearers with a web of 0.68 m. Face supports are Hemscheidt 320 tonne two-leg shields.

The 9E Panel has a planned length of 2600 m and dips a few degrees off strike giving a range of depths of cover from 550 m close to the deeps to 610 m at its furthest point. It is protected from the effects of the adjacent panel, 8E, by a 65 m wide barrier pillar.

The 6W Panel rises slightly from the strike, with a planned length of 1250 m and depths of cover of between 580 m at the face start and 550 m at the furthest point. It is separated from the 5W Panel by a 65 m barrier pillar.

GEOLOGY

Roadways are mapped regularly by CBDC geologists, so immediate roof and floor strata are well documented in both districts. No cored boreholes have been drilled in the 9E or 6W Panels, but logging of methane drainage borehole chippings undertaken by CBDC staff gives an indication of roof strata above the workings.

The 9E Panel has a softer floor and a higher frequency of sandstone channels and overbank deposits than the 6W Panel. This is also true of the east and west districts generally, although a sandstone channel did appear at the start of the 6W District. A generalised strata section is given in Table 1. Tables 2 and 3 give approximate strengths of similar rock types and coal specimens obtained from the coalfield.

GATEROAD SUPPORT

Maingates

Prior to the implementation of monolithic packing in the 9E District, the maingate pack consisted of a continuous row of 1.75 m x 1.75 m, 80% solid hardwood chocks adjacent to the arch. On the gobside of this was a 30 cm wide wall of stonedust in 25 kg bags and a 0.75 m x 1.75 m skeleton

Table 1 - Generalised strata section, Lingan Colliery

Freshwater siltstones and mudstones. Braided sandstone channels and overbank deposits represented by laminites and occasional sandy limestones occur mainly on the east side of the mine.
Harbour Seam: 2.1 m thick, 1.9 m on the west side.
Siltstone Seatearth: rootlets, listric surfaces, thicker on the east side of the mine.
Shale

Table 2 - Physical properties of comparable strata from elsewhere in the coalfield

Strata Type	Uniaxial Compressive Strength (MPa)	Tensile Strength (MPa)	Young's Modulus (GPa)	Poisson's Ratio
Sandstone	72-80	3.8-8.1	17	0.28
Siltstone	60-100	2.6-10.4	13-19	0.14-0.2
Mudstone	30	0.7-5.6	28	0.25
Laminite	57-67	5.4-7.7	11-15	0.16
Limestone	42.6	9.6	13	0.17

Table 3 - Physical properties of the Harbour Seam at Lingan Colliery

Point Load Index (Is_{54})	1.23
Uniaxial Compressive Strength (MPa)	11.8
Young's Modulus (GPa)	1.4-2.9
Poisson's Ratio	0.34
Ø Peak	30°
Ø Residual	30°
Permeability	8-14 microdarcies
Hardgrove Grindability Index	56-62

hardwood crib built just behind the panline. Intermittent 1.5 m x 0.75 m skeleton wood chocks were also built on the ribside where the coal is extracted to a distance of approximately 1.5 m below the ribside leg of the arch. The pack was usually built mid-way between the face and the ripping lip, a distance of approximately 8 - 10 m (Figure 3). The roadway support consisted of 120 mm x 90 mm 'I' section steel arches with a diameter of 4.2 m and 1.2 m splayed legs. The steel section was 29.5 kg/m. The arches were set at 0.9 m intervals strutted with 63 mm x 63 mm x 63 mm angle iron struts U-bolted to the arch and lagged over the crown with softwood. A Dosco DRCL MKIIA was used to cut the roadway.

The packing change was implemented by replacing the hardwood chock and the stonedust wall with a 2.1 m wide monolithic pack. The additional 30 cm in pack width was accommodated easily within the existing face end layout. All other gateroad support parameters remained constant, except for some additional wood or corrugated steel lagging between the monolithic pack and the arch leg to prevent excessive spalling into the roadway.

The Monolithic Packing System: 'Astrapack'

'Astrapack' is a low solids cement based packing material recently developed by Pozament Cements Limited to compete with the 'Tekpack' product offered by Foseco. The latter has been used in the U.K. with success for two years. 'Astrapack' was chosen for the trial after a competitive bidding process.

The trial was initiated in March 1985 after the panel had advanced 617 m. The 'Astrapack' system requires less material to be imported than 'Tekpack' or its predecessor 'Aquapack', a similar packing system also manufactured by Pozament Ltd. (Table 4). The placing equipment was left over from a previous short-lived experiment with 'Aquapack' elsewhere in the mine. The cement grout pump was mounted over the stageloader at the face end, with the bentonite group pump located outbye at the No. 4 deeps landing. A shutter built by CBDC to NCB design and locally made packing bags allowed the 2.1 m wide, 2.1 m high pack to be placed in 1.2 m increments, through this was later increased to 1.5 increments by using longer bags.

A preliminary report on the packing system employed at Lingan Colliery has been published (3) and for convenience is summarised in Appendix A.

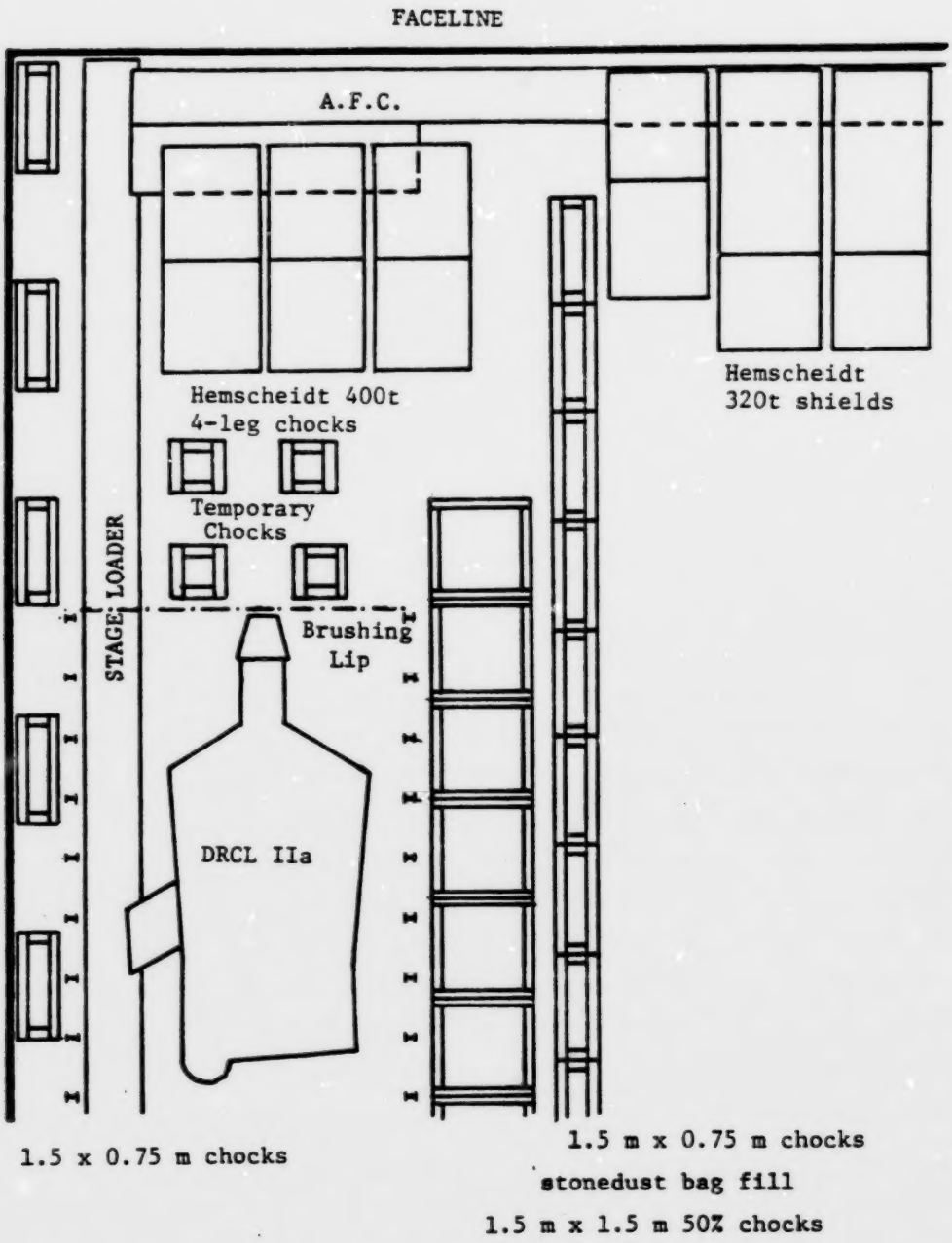

Figure 3 - Maingate support in the 9E Maingate prior to the implementation of monolithic packing

Table 4 - Mix ratios of 'Aquapack', 'Tekpack' and 'Astrapack' (quantities per m^3 of pack)

	cement component kg	bentonite/ accelerator kg	water kg
Aquapack	450	50	915
Tekpack	182	182	910
Astrapack	175	175	876

Tailgates

Conventional tailgate packing at Lingan Colliery consisted of a 60% hardwood chock and three skeleton cribs, 1.5 m apart. Each row of four chocks was spaced 1.5 m apart. The space between the chocks was filled (incompletely) with the ripping debris, shovelled in from the gateroad by hand. The final pack width was 6.0 m (Figure 4). In the 6W Tailgate a continuous row of 1.5 m x 1.5 m , 100% solid hardwood packs were built 4 - 5 m behind the faceline. Between the 1.5 m x 1.5 m pack and 0.75 m x 0.75 m skeleton crib was a 0.75 m space in which a brattice cloth was hung to seal the waste. The skeleton crib was built 3 - 4 m behind the advancing face, just behind the armoured face conveyor (Figure 5).

The roadway support consisted of 120 mm x 90 mm 'I' section steel. The new arches had a diameter of 4.27 m as opposed to the 3.65 diameter of the arches previously used in tailgates. Each had 1.2 m splayed legs. The new steel section arches were also heavier; 29.5 kg/m compared to 19.34 kg/m used previously. Arches were set at 0.9 m intervals with eight 63 mm x 63 mm angle iron struts U-bolted to the arch. Drill and blast techniques were used to cut the roadways at a ripping 7 - 10 m behind the faceline.

GATEROAD INVESTIGATIONS

Gateroad investigations to determine the effects of the packing changes on strata control consisted of two parts: detailed site investigations and surveys of gateroad heights.

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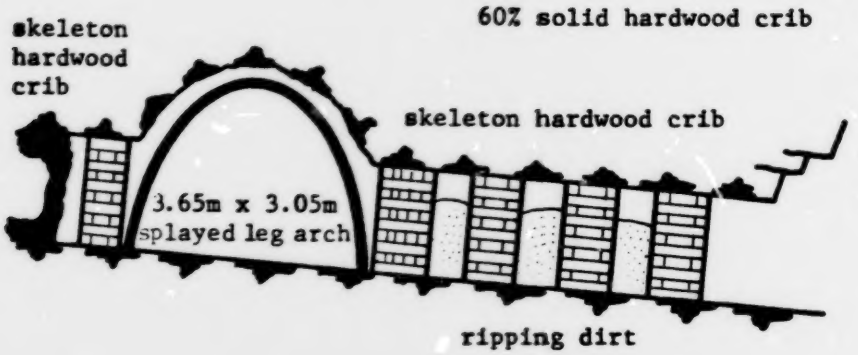


Figure 4 - Original tailgate packing method (9E)

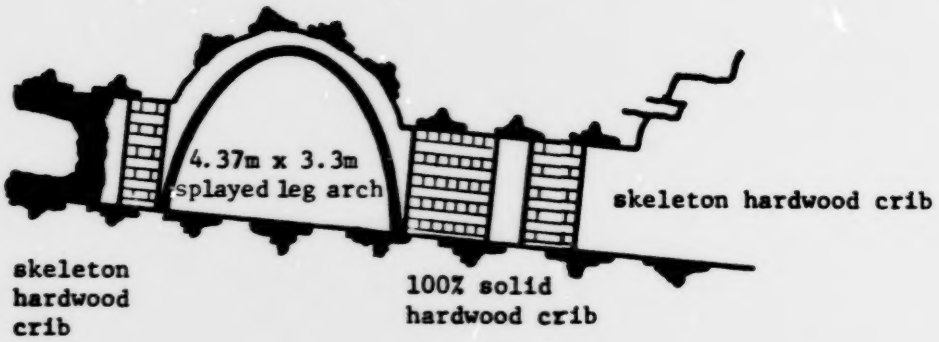


Figure 5 - New tailgate packing method (6W)

SITE INVESTIGATIONS

A total of five instrumentation sites were installed, three in the 9E Maingate and one each in the 9E and 6W Tailgates. Instruments were installed to measure pack load, pack closure and gateroad closure. At the site in the 6W District, an extensometer was used to measure movement in the coal ribside. Details of the instrumentation types are given in Table 5.

Pack instruments were installed on a regular working shift, taking care not to disrupt ordinary mining operations. Rock bolts in the gateroad were installed on the next off-shift.

Instrumentation at each site was monitored daily for the first week after installation and at a reducing frequency after that as the faceline moved away from the site. Despite the great care taken during installation to protect the instruments and their readout cables, several became inoperative or gave results which gave rise to a suspicion of malfunction after a short period of time. This is understandable due to the adverse conditions under which they operate and some losses in this manner are inevitable. Other readings were lost due to tampering, most noticeably convergence readings from rock bolts. Thus a complete picture of gateroad behaviour is impossible to obtain in some instances.

Table 5 - Instrumentation used in the investigation programme

Parameter	Instrumentation
Closure: Gateroad	- Rock bolts in roof and floor.
Closure: Packs	- Electronic resistance pack strut (Model Cor/P-R, Roctest Inc., Montreal).
Load: Packs	- Earth pressure cell, hydraulic readout 0-1000 psi (Solinst Canada Ltd., Burlington).
Differential Strata Movement	- Irad Gage Flexible Sonic Probe (Solinst Canada Ltd., Burlington).

GATEROAD SURVEYS

Surveys of gateroad height at 9 m (10 arch) intervals were taken to determine the deformation trend in the gateroad away from the detailed sites.

The simple tape surveys are quick and easy to conduct and allow rapid comparison of the effects of different gateroad conditions.

SITE DETAILS

9E Maingate

Three investigation sites were installed in the 9E Maingate, one prior to the packing change and two subsequently. Information concerning depth of cover, extracted height and other site-specific parameters is given in Table 6. A summary of instruments used at each site is given in Table 7.

Tailgate Sites (9E, 6W)

Two investigation sites were installed, one in the 9E Tailgate, the other in the 6W Tailgate. Information concerning depth of cover, extracted height and other parameters for both sites are given in Table 8. Table 9 summarizes the instruments used at the 9E and 6W sites.

Table 6 - Site-specific parameters, 9E Coal Road, Lingan Colliery

Parameter (Arch Number)*	Site 1 (560)	Site 2 (780)	Site 3 (990)
Depth of cover (m)	576	580	583
Extracted height (m)	2.17	2.10	2.11
Seam dip (degrees)	6.7	6.9	6.5
Pillar width			
Maingate (m)	infinite	infinite	infinite
Tailgate (m)	162.4	72	76.8
Rate of face advance first 4 weeks past site m/day	3.7	3.2	3.2

* Location of site from the start of the face.

Table 7 - Summary of instruments deployed at each investigation site in the 9E Maingate

	Convergence Bolts	Load Cell Pack	Pack Struts
Site 1	2 pairs, on rib and packside and a single centre bolt in the roof	4 in the 1.5 m x 1.5 m wood crib	2 in the pack, 1 in line with the bolt section
Site 2	As above	3 below the pumped pack, 2 mounted vertically to measure lateral load	2 in the pack
Site 3	As above	As above	1 in the pack

In addition, a 7.5 m extensometer hole was drilled vertically above the roadway at Site 3.

Table 8 - Site parameters - 9E and 6W Tailgate, Lingan

Parameter (Arch Number)*	9E (356)	6W (183)
Depth of cover (m)	548	556
Extracted height	1.93	1.52
Pillar width (m)		
Maingate	infinite	infinite
Tailgate	61	64
Rate of face advance m/day	3.2	2.5

Table 9 - Summary of instruments used at investigation sites in tailgates

Site	Convergence Bolts	Load Cell Pack	Pack Struts
9E	2 pairs, on rib and packside	6 load cells	4 pack struts mounted in 4 different packs
6W	2 pairs, on rib and gobside	6 load cells mounted in 1.5 m x 1.5 m, 100% solid hardwood pack	*2 placed between packs

* Malfunctioned

In 6W an extensometer was installed into a hole drilled 4.6 m horizontally into the coal rib.

RESULTS

9E MAINGATE

Convergence and pack stress data collected during the monitoring program for individual sites were treated manually, smoothed and adjusted for easier interpretation. This entailed averaging of load cells at individual sites and offsetting of closure curves to reflect different face locations at installation. These adjusted curves are shown in Figures 6 and 7.

Results from each site are very similar and indicate two phases of deformation. Phase 1, representing the effects of immediate extraction, extends to approximately 40 m behind the faceline, after which closures and loads begin to settle into the time dependent Phase II which begins approximately 100 m behind the faceline. Pack stress rise as Site 2 is noticeably more rapid, altering to the Phase II state after only 40 m of face advance.

Two gateroad height surveys were conducted in which clearance from the arch crown to the roadway floor was measured every tenth arch along the entire gateroad. Both gave very similar results, represented graphically in Figure 8 as one curve. Face advance in two-week time increments is also illustrated in Figure 8.

TAILGATES (9E, 6W)

The convergence and pack load measurements compiled during the tailgate monitoring program are presented in Figures 9 to 12.

Results from each site indicate two distinct phases of strata movement. Phase 1 represents the immediate effects of the extraction of the coal, lasting until 30 - 60 m after the face was cut. Deformation then settles to a time dependant rate (Phase 2). Pack loads and closures at both tailgates rise rapidly in Phase 1 and then remain stable in Phase 2. This is typical of each phase.

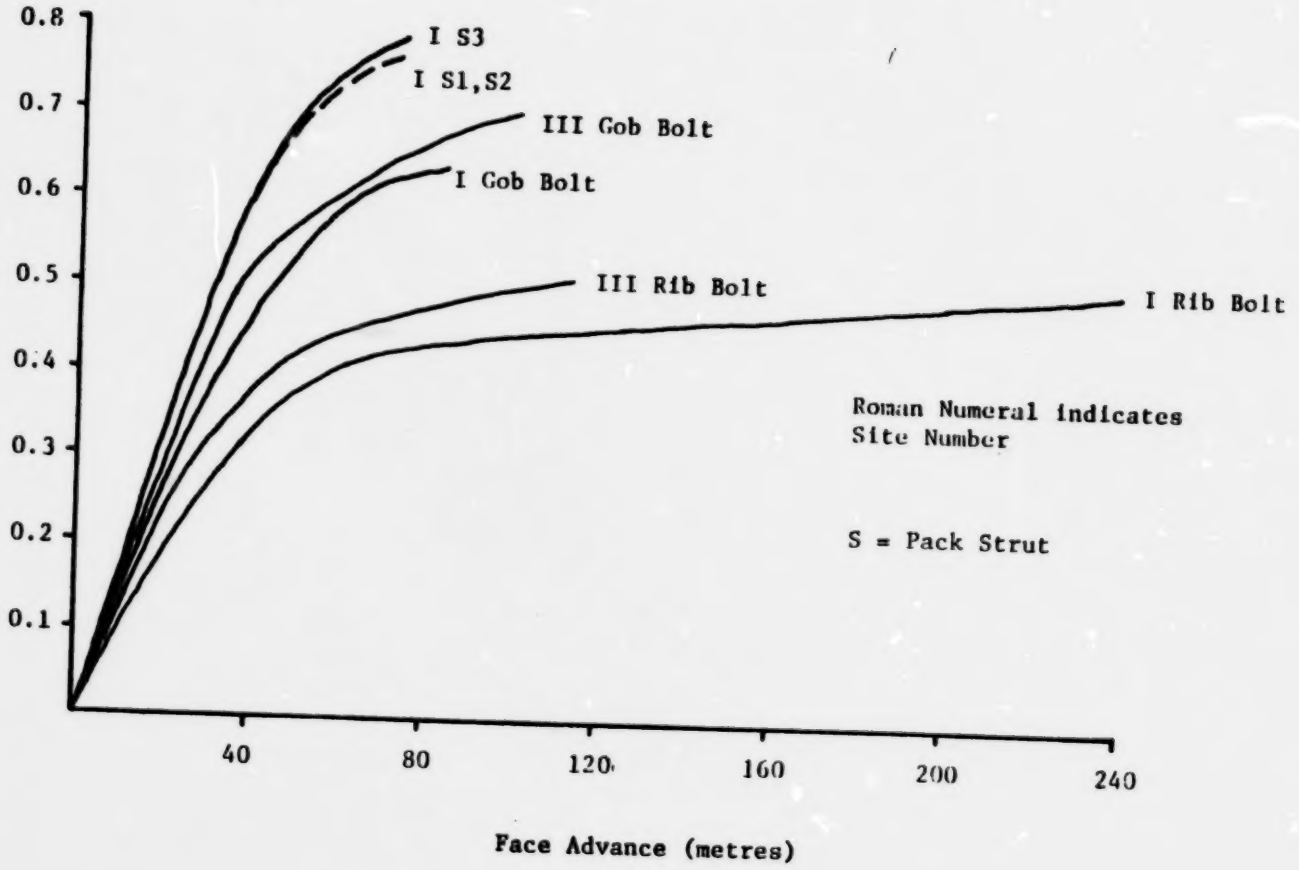


Figure 6 - Adjusted closure results, 9E Maingate

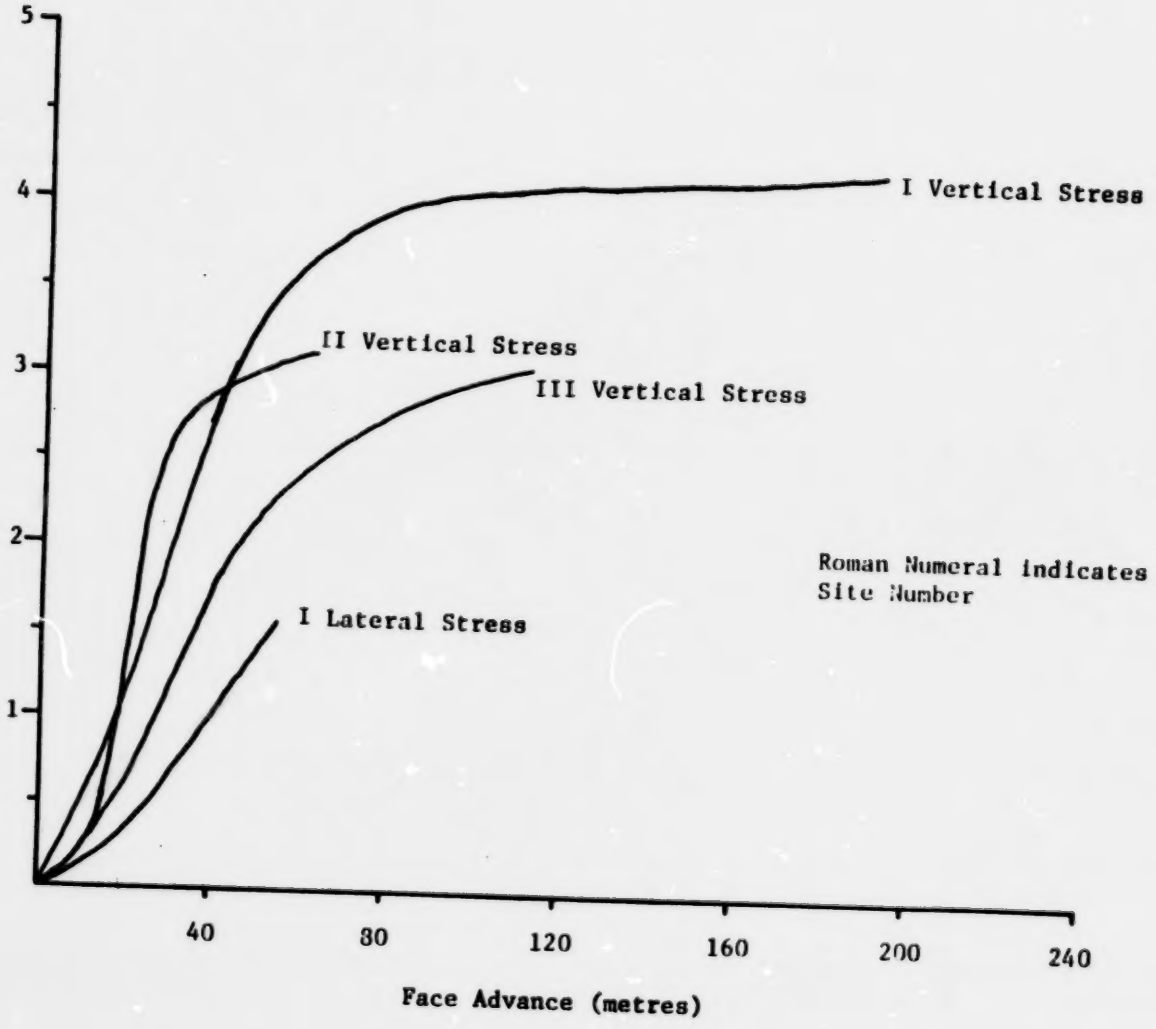
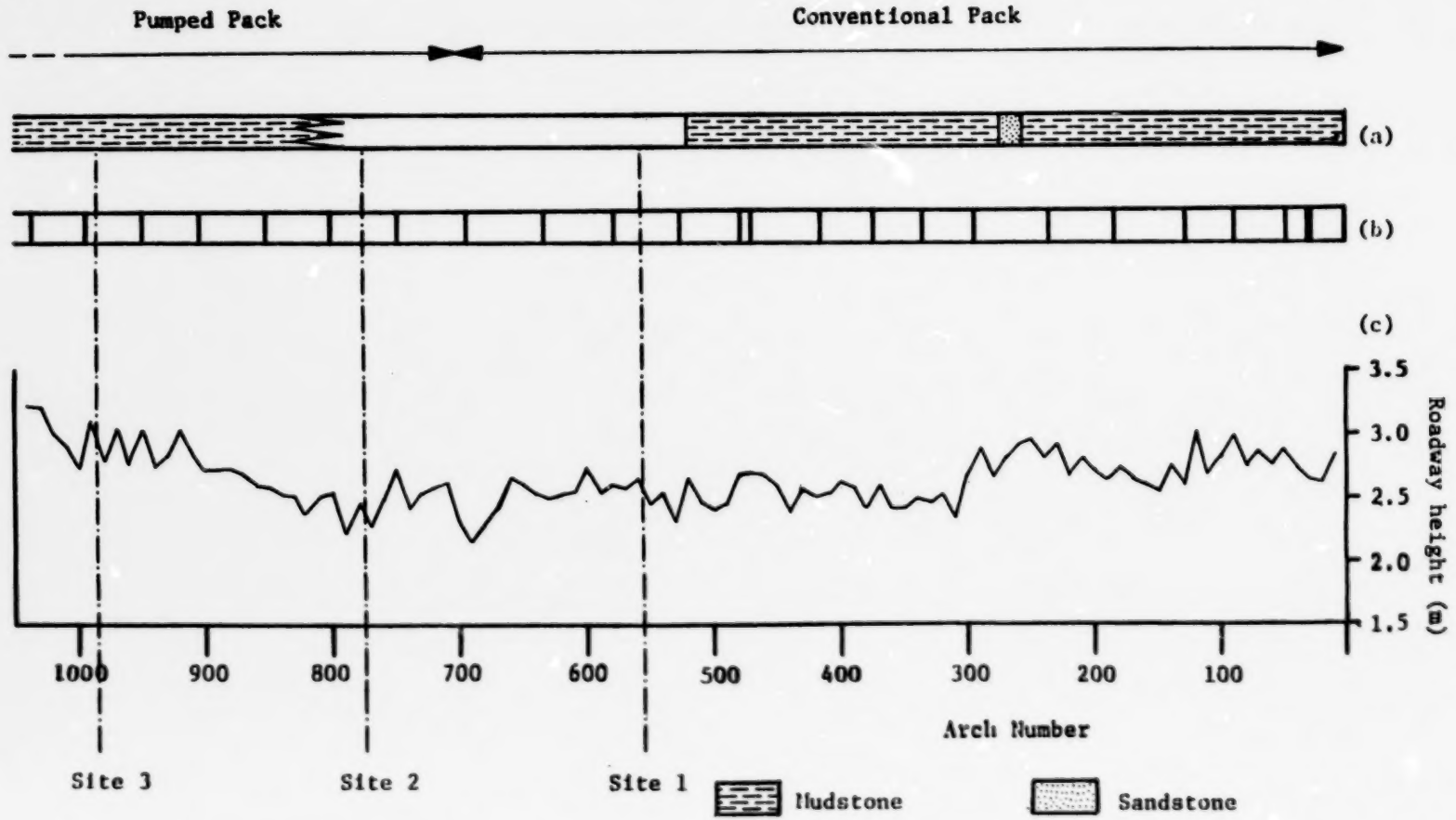


Figure 7 – Adjusted load results, 9E Maingate



a) Generalised roadway geology

b) Face advance in two week increments

c) Roadway height (last arch 1041)

Figure 8 - Location of investigation sites in the 9E Maingate with respect to roof geology and face advance and showing gateroad height profile

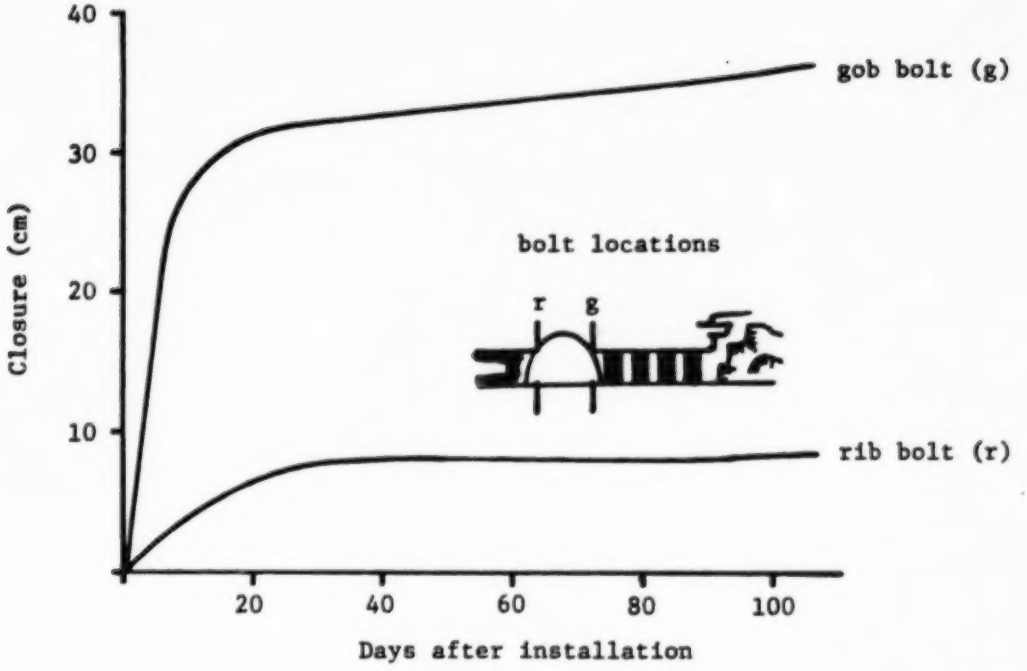


Figure 9 - Closure, 9E Material Level

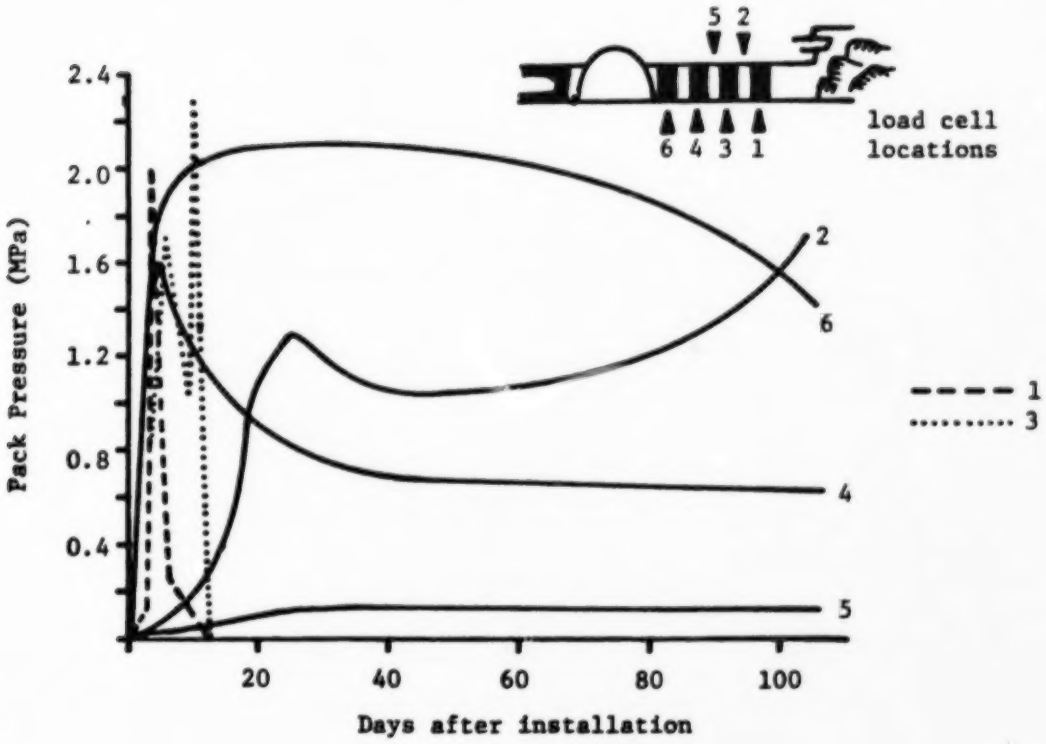


Figure 10 - Pack pressure, 9E Material Level

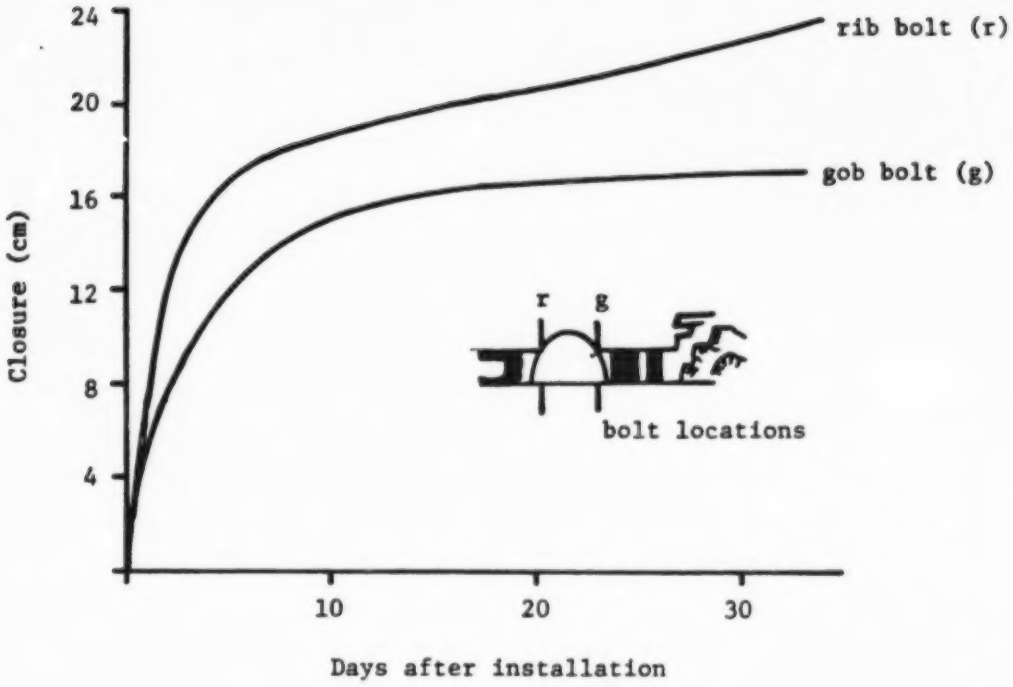


Figure 11 - Closure, 6W Material Level

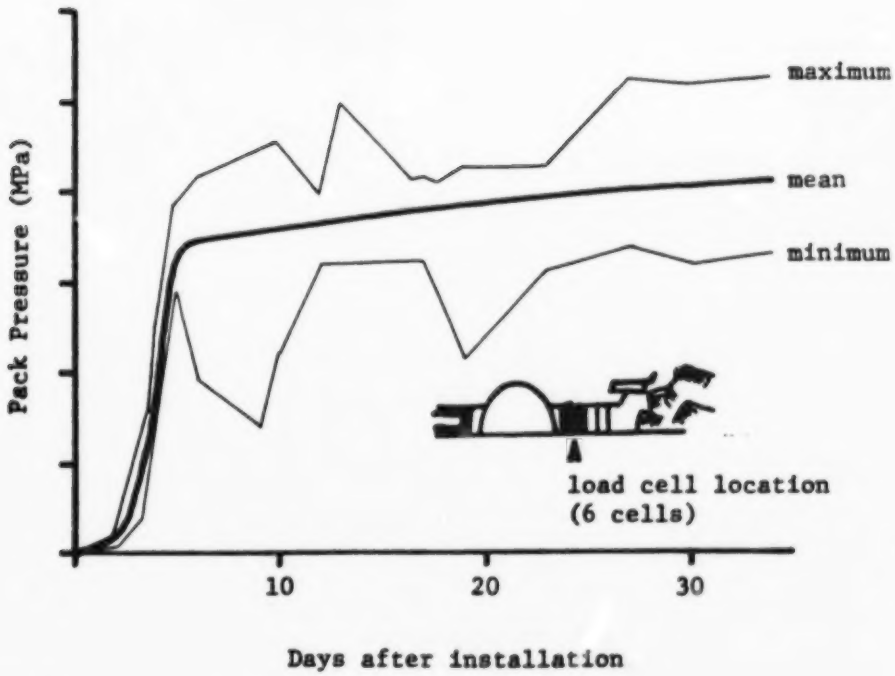


Figure 12 - Pack pressure, 6W Material Level

The sites show loading and deformation patterns typical of those elsewhere. However, the larger rib side convergence in 6W was not typical of other sites. This closure may be result of the undercutting of the coal to a distance of 1 - 1.5 m on the ribside. A continuous row of weak skeleton cribs set on unconsolidated coal duff supports the ribside.

Table 10 - Summary of results

		Time (days)	Average Load (MPa)	Rib Bolt Closure (m)	Gob Bolt Closure (m)
9E	Phase 1	0-20	1.01	5.4	29.9
	Phase 2	20-	0.98	3.4	2.4
6W	Phase 1	0-10	2.60	16.0	15.1
	Phase 2	10-	3.95	7.6	1.9

Gateroad deformation surveys were not carried out in the 6W Tailgate, but a survey was carried out in the 9E Tailgate some time after the new packing system was implemented there. Average gateroad height prior to the packing change was 2.24 m, compared to 2.46 m after the change. The 22 cm difference represents a 10% increase in the residual gateroad height due to the packing change.

DISCUSSION

The results can be discussed in terms of the maingates and tailgates.

MAINGATES

The information given above reveals only two marked differences between each of the investigation sites; the roof geology and the method of packing. Sites 1 and 2 are directly comparable, being in the same geological setting and differing only in packing method. However, the absence of closure data for Site 2 makes such a comparison impossible. Pack load data for Site 2 reveals a more rapid load development there compared

to other sites. In the absence of closure data, this is difficult to evaluate, but it could be due to several factors acting singly or in combination:

a) a higher cement content in the Site 2 pack, giving a more rapid strength development in the early stages,

b) closures at Site 2 immediately behind the faceline due to the stronger roof strata, allowing maximum strength and stiffness development in the pack prior to subsequent loading, and

c) less pack confinement on the gobside and roadside at Site 3.

Closure results at Sites 1 and 3 indicate very little difference between the two sites, although convergence at Site 3 is marginally higher.

The gateroad survey results also tend to agree with a conclusion that the stability of the gateroad has been maintained, and also that closures will ultimately be less in the zone of mudstone roof and pumped pack (Figure 8). This is as yet unproven due to the proximity of the faceline to the roof geology transition point at the time of the survey. An additional observation is that the first 300 arches of face advance are subject to less closure, possibly due to bridging of the strata across the substantial pillar at this point and therefore resulting in incomplete gob compaction. This would result in higher ventilation losses in this area, a conclusion reflected in practice. The maintenance of an efficient gob seal in this zone is therefore of utmost importance to the improvement of ventilation efficiency.

The original design for the 9E Coal Road pumped pack was formulated on the basis of results from the 8E Coal Road, which indicated a support resistance of 6.75 - 8 MN/m of gateroad. This is the total pack resistance at the start of Phase II of the deformation process. Results from the 9E Coal Road give resistance of 5.85 MN/m and 6.3 MN/m for the conventional and pump packed section respectively. Although comparable, these are lower than those experienced in the 8E Coal Road, possibly due to a difference in the site conditions. It should be noted that the original design of a 1.5 m wide pack, suggested by CBDC, would offer only 4.5 MN/m of resistance on the basis of these results, well below the required value.

The overall conclusion to be drawn from the results is that the stability of the gateroad has been maintained, although observation should be continued to monitor long-term effects and changes in site-specific parameters.

TAILGATES

The 9E and 6W Tailgates were similar in geological setting and differ only in packing method and roadway support. The 9E and 6W steel supports had a weight per cubic metre volume of extracted roadway of 17.77 kg/m^3 and 24.11 kg/m^3 respectively. The 9E steel arch weighed 158.3 kg while the larger 6W arch was 272.1 kg. This is a significant increase in steel spending. However, the support resistance of the steel arches is small (0.1 MN/m^2) when compared to the pack resistance. Therefore, the pack is the major component in controlling strata movement.

Roadway deformation was the main cause for concern in conventionally packed tailgates. The 9E and 6W sites had 12.6% and 5.1% closure respectively. The 50% reduction in closure of the gobside was a direct result of the new pack.

A computer programme, developed by CBCRL, was used to calculate pack resistances. The conventional pack obtained a resistance of 4.5 MN/m after 60 m face advance. The new pack resistance after 60 m face advance was 6.0 MN/m. Figure 13 shows a comparison of pack resistance development at each site. The new pack reaches peak resistance after 35 m face advance. The old pack type shows a very slow rate of resistance increase.

The new packing method used in the 6W Tailgate was so successful at reducing roadway closure that shortly afterwards it was implemented in the 9E Tailgate.

CONCLUSIONS AND RECOMMENDATIONS

The results show conclusively that the two recent changes in packing method implemented at Lingan Colliery have resulted in benefits to colliery operations. In the maingates, the monolithic pumped pack has maintained support whilst reducing ventilation leakage. In the tailgates, the new wooden pack design has increased the pack resistance by a considerable amount with a consequent improvement in strata control. The most important factor in these investigations was the knowledge of gateroad deformation behaviour prior to and after the packing changes both for the design of the new systems and the interpretation of the results.

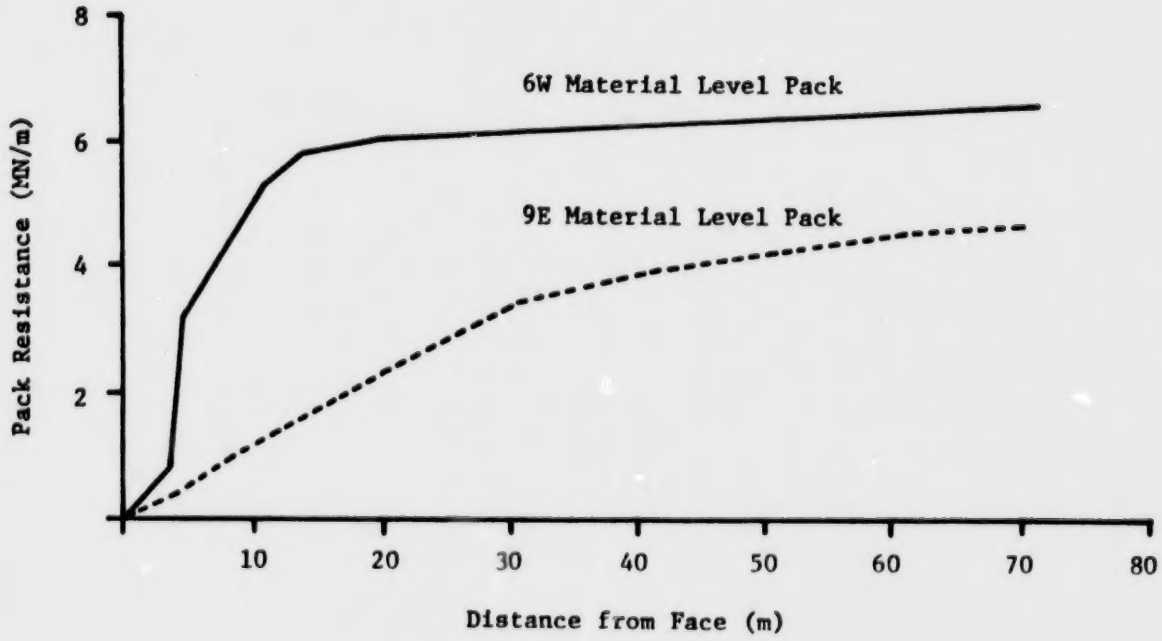


Figure 13 - Pack resistance development against face distance for 9E and 6W Tailgate packs

The sole recommendation of this report is that the research programme be continued, and if possible extended, so that additional data can be obtained. This will allow a more refined pack design method to be adopted in future gateroads.

ACKNOWLEDGEMENTS

The encouragement and assistance of CBDC management and staff, especially at Lingan Colliery, is gratefully acknowledged. Thanks are also due to colleagues at CBCRL who assisted with site installation and monitoring.

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APPENDIX A

The 'Astrapack' Packing System at Lingan Colliery

Very high levels of air leakage through the longwall wastes threatened to disrupt production on the east side of Lingan Colliery where two adjacent longwalls were operating. In order to alleviate the leakage problem, the Cape Breton Development Corporation (CBDC) opted to install a monolithic pump packing system in the 9E Coal Road to improve gob sealing and reduce leakage. Some experience with monolithic packing existed within CBDC as a result of a trial of an 'Aquapack' pump packing system on the 3W Coal Road in the spring of 1982. In this instance the pack width was only 1 m and the result was more in line with a gateroad sealant than a fully supportive pumped pack.

To economise for the trial period, CBDC chose to use the 'Aquapack' placement equipment which was refitted in the colliery workshops. Since the 1982 trial, developments in pumped pack cement technology has resulted in the commercial availablity of two similar products which required 20% less material than the 'Aquapack' system. Both products are manufactured in the United Kingdom. 'Tekpack' (Foseco) has been used there with some success for 18 months. 'Astrapack' (Pozament Cements Limited) is a relatively new competing product. Both products comprise two components, a high alumina cement blend ('Tekcem' and 'Astracem' respectively) and a bentonite/accelerator blend ('Tekbent' and 'Astrabent' respectively) which are mixed separately and pumped to the packhole prior to entering a bag which holds the mix until it sets. 'Astrapack' was chosen for the 9E trial over 'Tekpack' as the result of a competitive bidding process.

UNDERGROUND INSTALLATION

The underground installation of the pump packing system employed two mixing/pumping stations for the 'Astrabent' and 'Astracem' slurries (Figure A-1).

The 'Astrabent' mixing/pumping station is located at the junction between the 9E Coal Road and No. 4 deep. A Colcrete type 5D continuous colloidal mixer is connected to an Evans MK64 piston pump. Both are powered from the same eletrohydraulic power pack comprising a 55 kW (75 hp) electric motor coupled by a Reynolds chain to a Colcrete hydraulic pump delivering 64 L/min (14 Imp gal/min) to the pump and 45 L/min (10 Imp gal/min) to the mixer. The hydraulic pump is cooled using water from the mine main which is reduced from 3.44 MPa (500 psi) to 1.4 MPa (200 psi) at a pressure reducer

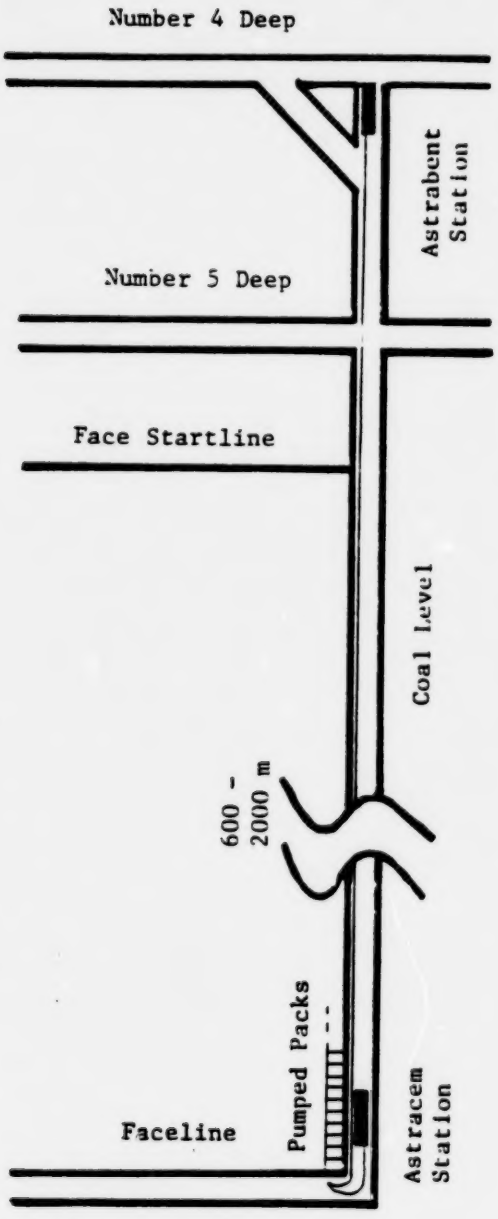

Figure A-1- Schematic layout of pump packing equipment in the 9E Hairgate, Lingan Colliery

prior to use. 'Astrabent' is fed into the mixer at the rate of 25 kg/min (55 lb/min) from an integral hopper via a vertical screw feeder powered by the hydraulic pump. The colloidal mixer is set at 1000 rpm with a water feed for 64 L/min (14 Imp gal/min). Feed rates, mixer speeds and pump output are regulated and calibrated by controls on the mixing/pumping stations. Station dimensions are given in Table A-1.

Table A-1 - Dimensions of mixing/pumping station components

Component	length (mm)	width (mm)	height (mm)
Power pack	2700	1000	1000
Mixer	1650	920	1180
Pump	3250	715	900

The mixed 'Astracem' slurry is pumped to within 100 m (300 ft) of the face in 2.5 cm (1 in) diameter water pipe at which point flexible hose is used to carry the slurry to the mixing/delivery nozzle at the packhole.

The 'Astracem' station straddles the floor mounted stageloader approximately 30 m (100 ft) from the coalface. The mechanical details, feed rates and flow rates are exactly the same as those of the 'Astrabent' station except that 'Astracem' is the material used to make the grout. The 'Astracem' is then pumped in 2.5 cm (1 in) diameter flexible hose to the mixing/delivery nozzle at the packhole where it splash-mixes with the 'Astrabent' slurry prior to entering the packing bags.

The packing bags are manufactured in Sydney, Nova Scotia from Novathene GMB 2, a plasticised flame retardant antistatic material approved for pump packing use by Labour Canada. The material was developed jointly by Polymer International of Truro, N.S. and Premium Distributors, Sydney, N.S. and the bags are made and marketed by Premium Distributors. The bags are 2.4 m (8 ft) high, 2.1 m (7 ft) wide and 1.5 m (5 ft) long, and are fitted with ties to allow correct hanging in the packhole. The packs are installed in 1.5 m increments.

In addition to the mechanical elements of the packing system, each pumping station and the packhole has a dedicated communications system to allow control of the pump process.

The pack shutter was made to an NCB (U.K.) design by CBDC. It is a hinged two-piece steel cage with vertically oriented shooting bolts at intervals around the top to allow the packing bag to be raised to the roof. The shutter is supported by four Dowty hydraulic props when the bag is being filled.

PACKING PROCEDURE

The initial stages of the pump packing trial were assisted by personnel from Pozament Cement Limited and Colcrete Ltd. of the U.K., suppliers of the packing material and pumping machinery respectively.

The first stage of the packing procedure is the erection of the shuttering and hanging of the bag, taking care to ensure that no folds can develop in the bag and that no sharp objects in the packhole can burst it. The 'Astrabent' pump is then activated, delivering 64 L/min (14 Imp gal/min) of 'Astrabent' slurry. When the whitish slurry is observed at the mixing nozzle the 'Astrabent' pump is stopped and the same procedure followed with the 'Astracem' pump. When the dark brown 'Astracem' slurry is seen at the mixing nozzle the 'Astracem' pump is stopped, the mixing nozzle is placed in the packing bag and both pumps are restarted and run until the bag is full. A non-return flap on the packing bag assists sealing when the nozzle is removed upon the completion of the pack.

The specified strength of the 'Astracem' pump packing material after one hour (0.5 MN/m^2, 72 psi) allows the removal of the shutter at that time. The cement pump and line is flushed out after each pack is placed to prevent remnant cement grout from setting in the delivery line. When the pack has set, the shuttering is removed and advanced and the packing cycle begins again.